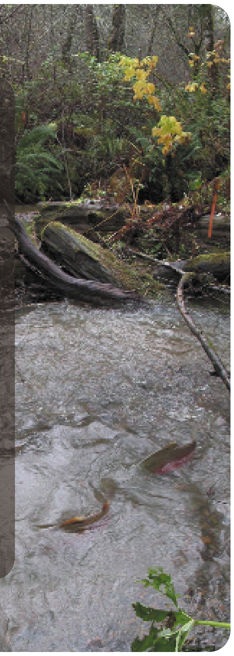


Upgrading and installation of fish passages and fish screens, offstream water storage

Upgrading and Installing Fish Screens: Developing Cost Estimates

R. DENNIS HUDSON
U.S. Bureau of Reclamation, Pacific Northwest Region
1150 N Curtis Road, Suite 100
Boise, ID 83706-1234
rhudson@pn.usbr.gov

ABSTRACT

This paper uses upgrading and installing fish screens to discuss the development of cost estimates for projects on both single site and watershed levels. Included in the discussion is the process of determining costs for an individual project in the planning stages, from a reasonable first approximation to a final refined cost estimate. Also considered are the feasibility of estimating costs on a larger scale and some of the processes by which these estimates might be developed.

INTRODUCTION

About 16 years ago, the Bureau of Reclamation (USBR) began the process of upgrading fish screens in the Yakima River Basin, Washington. The 20 major mainstem diversions chosen for work had flows that ranged from a few hundred cubic feet per second (CFS) to a few thousand. In 1984, the initial estimate for upgrading those 20 diversions with fish ladders and fish screens was $16–17 million, based on a rate of $1,500 per CFS. After appraising the sites and calculating a first approximation of reasonable project costs, USBR doubled the estimated cost to $35 million. By 1990, we had finished the first phase of the work and the cost had reached $60 million.

Cost estimation is a difficult process that requires flexibility and the ability to incorporate into the budget unexpected changes in the project plan. Estimating costs for fish screening projects generally begins with the development of design criteria for the screens. A first approximation of cost can then be developed based on these criteria and on the specific environmental and regulatory conditions at the project site. This first approximation will then be altered as the project design is refined and as the regulatory requirements are met.

Developing cost estimates on a watershed or higher level is more difficult, and requires a method for developing a generalized cost framework. One such method is the creation of cost curves based on previous fish screen projects in a given state. These curves can provide very rough estimates of project costs based on the size of the screen to be constructed.

ESTIMATING COSTS AT THE PROJECT LEVEL

Upgrading and Installing Fish Screens

In many cases, upgrading fish screens is not feasible. Existing fish screens are typically 20–30 years old. The design criteria have changed so much over the intervening years that it is usually not practical to fit a new structure into the existing screen structure. Often the new structure will have three times the screen area of the existing structure. On a couple of sites, it has been possible to retrofit an existing structure and fit a different kind of screen in, which saves a little money. Usually, however, we end up tearing out the old structure—or even leaving it in place—and building a brand new structure.

Most USBR screens have been built by contract. The Bureau does the design work, then hires a contractor to build the screens. The State agencies also build screens by contract, but they also have their own crews and build some of their own screens, which saves some money.

The type of contract used in the project can have a significant impact on the project cost. Whether the contract is Federal with Federal funding, State without Federal funding, or private can make a big difference in cost as a result of the contracting procedures and requirements.

There are some alternatives to upgrading or rebuilding screens. On one site, we eliminated a small diversion altogether. Then we wrote a grant for a couple of landowners to excavate some wells in the gravel next to the river and put in sprinkler systems. This action was beneficial for both the landowners and the fish. There have been other situations where we have combined diversions, eliminating one diversion point and placing a slightly bigger screen on another.

Design Criteria

In developing cost estimates on a watershed or larger scale, the design criteria are a major factor. Also important are the size of the diversion and the specific site conditions. Costs can vary widely within these categories.

With regard to design criteria, the Endangered Species Act (ESA) has produced a great deal of fear, not only in water users but also in State and Federal agencies. Because the water users have observed some ESA enforcement actions, they are concerned and are looking for help in order to make their diversions compliant and thereby avoid having their operations shut down. The National Marine Fisheries Service (NMFS) has very specific design criteria that dictate how a fish screen should be laid out and how it should function. NMFS is generally unwilling to make exceptions to these criteria because they do not want to open themselves up to litigation from an environmental group or others. Although USBR has good working relationships with NMFS and other agencies, it seems as though the trust that has been developed over the years has eroded to some extent.

In the past, at a few sites, USBR designed the fish screens to fully meet design criteria for about 95% of all expected diversions. On rare occasions (5% of the time), the criteria would be compromised somewhat, but the screens would still provide effective fish protection. These designs were approved by NMFS on a case-by-case basis after review of canal operational scenarios and consideration of the likelihood of fish presence during the times that criteria might be slightly compromised. Due to the ESA listings, NMFS no longer will even consider such designs. As a result, the need to meet very rigid ESA design criteria has led to increased project costs at some sites. For example, at one site, a pumping plant built on a bend of a river had tremendous sediment problems. A decade ago we looked at a number of alternatives to reduce sedimentation. The best solution was to block off part of the channel, reroute the river, and bring water into the lower end of the channel; this solved the sediment problem. Now USBR is upgrading the screens, and NMFS and others are insisting that we reopen that channel. This will require us to put in new headgate structures and a desilting basin in addition to building screens. Where we initially estimated that we could replace the screens for $1 million, our estimate now is about $6 million. Unfortunately, this stream is in an area where the fishery resource is fairly marginal. The question then arises: is this where we want to spend our money, or would we be better off spending half of that money somewhere else where there might be a more significant improvement and where there might be more fish to protect?

Currently, the USBR screening budget is limited. All funding for our budgets comes from Congress. Projects often have to be postponed until sufficient funding becomes available; in some cases, enough money is never found. As a result, many tough decisions must be made about where and how to work.

Developing Site-Specific Costs

Once we know the design criteria, have an idea of the flow through the diversion, and know some minimal site information, we can come up with a first estimate of cost. These data are often obtained by comparing the site with a similar site or using an historical cost. Then we make adjustments to the cost based on specific variations at the site and our own judgments about what will be appropriate at a given site. For operations and maintenance costs, at this stage we normally include a percentage: 2.5% of the construction cost.

Because most USBR screens are built by contract, we can estimate a cost per contract for an initial first approximation. Typically, we will also include a percentage (usually 25 to 40%) of the contract cost to cover data collection and design work, contract administration, construction supervision, and environmental requirements. In some cases, though, the costs for these items have been twice that much.

It is sometimes the case that we end up designing a project three times before we are finished. Because we want to obtain a refined cost on a site-specific basis, we gather detailed design data, topography, water surface elevations, cross sections, and whatever else is needed to define the site and the problem, including the flow records for the diversion. With all of this information, we put together a conceptual plan and a layout showing the outline of the structure with some preliminary hydraulic studies so that we know that the structure will work.

At this point, the project is not designed down to the nuts and bolts, but there is a structure laid out. This structure provides an idea of the size and the thickness of the walls and the heights and sizes of the screens. From this plan, we will develop estimates of quantities needed of earthwork, riprap, concrete, pipe, and screens. To these quantities we can apply unit prices developed from recent jobs. Taken together, these figures provide a reasonable estimate of the project cost, which includes contingencies that allow for unexpected conditions.

Table 1 is a cost summary for the Fogarty Fish Screen in the Yakima Basin. This summary is used to demonstrate typical costs for a screening project. On this particular project, USBR started the preliminary work in 1995. Through the Fish Passage Program in the Yakima Basin we set up a technical work group with representatives from NMFS and the U.S. Fish and Wildlife Service plus Washington State and the Tribes and irrigation districts. All plans were submitted to these groups, and we arrived at a consensus on a project that we could move ahead with.

On this site, the consensus was to put the screens in front of the head gates on the

Table 1. Fogarty Fish Screen 8-1-96 (revised 8-8-97 & 3-18-98)

Item	Schedule	Est. Quantity	Unit	Unit Price	Amount
1	Mobilization and preparation	Lump sum	7%	ls	$21,000.00
2	Clearing and grubbing	Lump sum	ls	ls	$5,000.00
3	Diversion and care of stream	Lump sum	ls	ls	$10,000.00
4	Excavation, common canal	305	cy	$10.50	$3,202.50
5	Excavation, common structure	304	cy	$10.50	$3,192.00
6	Excavation, common pipe trench	180	cy	$9.00	$1,620.00
7	Backfill about structures	61	cy	$6.00	$366.00
8	Select bedding, pipe trench	32	cy	$4.00	$128.00
9	Backfill, pipe trench	134	cy	$12.00	$1,608.00
10	Compacted backfill, structure	61	cy	$6.50	$396.50
11	Compacted backfill, trench	32	cy	$9.00	$288.00
12	Compacted embankment – canal	719	cy	$12.00	$8,628.00
13	Riprap	10	cy	$45.00	$450.00
14	Furnish and lay 15″ pvc pipe	310	lf	$30.00	$9,300.00
15	Reinforced concrete in structures	79	cy	$800.00	$63,200.00
16	Cement		cwt	$6.00	
17	Reinforcing steel		lb	$0.65	
18	Miscellaneous metal work	Lump sum	ls	ls	$7,500.00
19	Trashrack	144	sf	$35.00	$5,040.00
20	Steel screen drum assembly	5580	lb	$3.50	$19,530.00
21	Stainless steel woven wire fabric	1010	lb	$3.50	$3,535.00
22	Overhead screen support structure	4375	lb	$3.00	$13,125.00
23	Motor & drive mechanism	880	lb	$4.00	$3,520.00
24	3-ton hoist	200	lb	$15.00	$3,000.00
25	Steel walkway grating	2930	lb	$2.50	$7,325.00
26	1″ pipe handrails	1805	lb	$2.00	$3,610.00

Table 1. Fogarty Fish Screen 8-1-96 (Revised 8-8-97 & 3-18-98) (cont'd.)

Item	Schedule	Est. Quantity	Unit	Unit Price	Amount
27	Timber stoplogs		fbm	$0.80	
28	4″ gravel surfacing	144	sy	$13.00	$1,872.00
29	7′ high chain fencing	431	lf	$25.00	$10,775.00
30	F&I 24″ x 48″ slide gates	3	ea	$2,000.00	$6,000.00
31	Accessory electrical equipment	Lump Sum	ls	ls	$10,000.00
32	Remove existing screen structure	Lump Sum	ls	ls	$12,000.00
33	Power Line modifications	0.25	mi	$40,000	$10,000.00
34	F&I 48″ CMP @ headworks	Lump Sum	ls	ls	$12,000.00
35	F&I ramp flume	Lump Sum	ls	ls	$3,500.00
36	Replace screen at on-farm pump	Lump Sum	ls	ls	$1,500.00
37	Canal reshaping & trimming	1300	cy	$25.00	$32,500.00
38	Allowance for unlisted items	Lump Sum	10%	ls	$27,000.00
TOTAL FOR SCHEDULE					**$321,711.00**
Contingencies @ 25%					$80,289.00
FIELD COST					**$402,000.00**
Indirects @40%					$161,000.00
TOTAL CONSTRUCTION COST					**$563,000.00**

river. We also agreed that we would not need to take fish into the canal. After we had started the final design work, though, the biologists changed their minds, deciding that it would be better to put the screens on the canal. This would mean that fish would go down a little bypass to a side channel that feeds back into the river. This design change prevented the project from starting until the next year, and time had to be spent redoing the design before the next construction season. As a result, the project cost increased dramatically.

Another complication in the Fogarty Fish Screen project concerns access to the work site. Bonneville Power Administration (BPA) had obtained right-of-way for the screen structures but had been unable to get the necessary access road easements. BPA does not want to use eminent domain to obtain the property. As a result, we have been trying to get right-of-way on an easement for an access road for three years. The project is on the schedule now for the fall of 2001. If we cannot obtain the right-of-way, however, the screen will probably not be built. The

Fish Passage Program in the Yakima Basin is nearing completion and we may run out of funding for the Fogarty project. This project provides a good example of the kinds of unexpected problems that can arise and potentially derail even well planned work that really needs to be done.

ESTIMATING COSTS ON A LARGER SCALE

In attempting to develop cost approximations on a larger scale, it is important to consider a number of different types of information about the project. These factors include unit costs for project materials, information requirements for project planning, the availability of large-scale data sources for comparisons between projects, and the level of confidence in the data used for comparison.

Unit Costs

There is not generally much difference in unit costs for fish screens between specific sites and watersheds. However, there are some opportunities to reduce costs when a larger scale is considered. If several diversions are grouped into one contract, there can be notable savings in the cost per screen.

Site Information

On a larger scale, the information needed to make a reasonable approximation of cost is similar to that needed on a single site basis. With a watershed, for example, it is important to know the number of diversions in the watershed and the sizes of those diversions. This information might be gathered as a range of sizes or as typical sizes of the diversions. Even without such detailed information, it is usually possible to make an educated guess.

For example, the states did screen inventories about ten years ago, and Oregon estimated about 3,000 diversions in the State should be screened. Washington and Idaho also did screen inventories, so information about diversions needing screening in these three states should be readily available. However, these inventories are now ten years old and need updating. In addition, it is very likely that the inventories were not comprehensive. A group of water users in the Klickitat Valley in Washington has developed a list of several hundred diversions that need screening in that valley alone. Most of these diversions probably did not show up in the Washington State inventory. As more people decide to take action on this issue, it is very likely that many more undocumented diversions will be found.

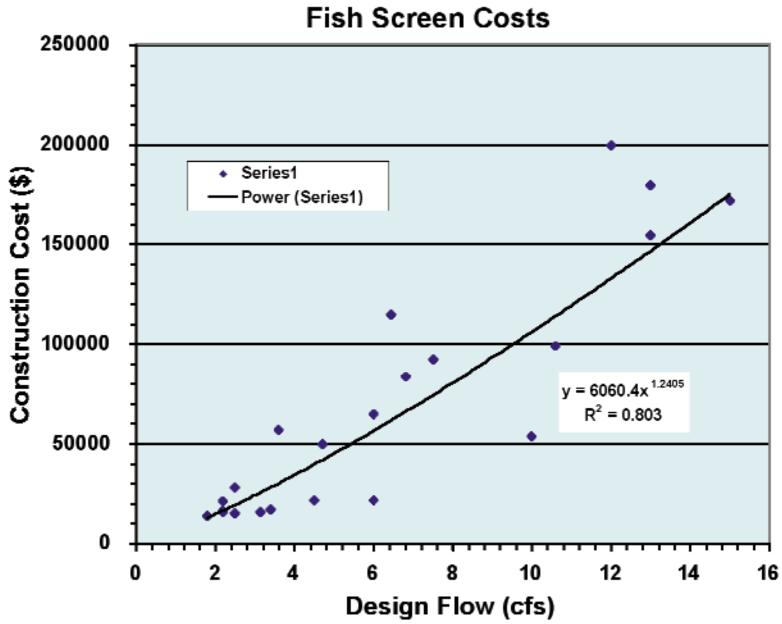
While it is possible to make larger scale approximations of cost within a given watershed, it is much more difficult to compare and aggregate costs between watersheds. There are too many differences between the specific conditions in watersheds to generalize beyond a single watershed level.

Cost Information

Next, cost information is needed to apply to the site information in order to develop a cost estimate. Historical costs for projects in the area are useful when they are available. We have some records of historical costs on USBR projects, but they are not always in a usable form. It is sometimes necessary to do some digging to get the right information out of the records, because it is not always obvious what features are included in a specific line item in a budget. In some cases, the cost for fish screens cannot be determined separately from other work that was included in the same budget.

When historical costs are not available, another option is to develop generic cost estimates. Plotting the costs of typical screens against their sizes on a graph and fitting a curve to the points can do this. Developing these curves requires a source of screen cost information for a variety of screen sizes. One place to start is with the states which have

Figure 1. Washington State fish screen costs, 1 to 15 CFS



compiled cost information on screens that they have built. On the Idaho Department of Fish and Game web site are listed fish screen costs for the last five or six years. Planning, engineering, materials, and subcontracting categories break out these costs. The State of Washington web site also has a table of some screens with size and cost per CFS.

Data Confidence

It is important to remember that if data is to be synthesized from a variety of sources into a single database for developing cost curves, the costs must be adjusted so that they are comparable. The contents of project budgets can vary widely, so that while one budget may only include labor, materials and operating costs, another may include those items as well as project design, construction supervision, contract administration and overhead. Differences such as these make the two budgets incompatible, and they should not be used in the same curve unless they can be adjusted to match. The real difficulty arises when it is not clear just what items are included in a set of cost figures. In this case it is important to be cautious when making comparisons.

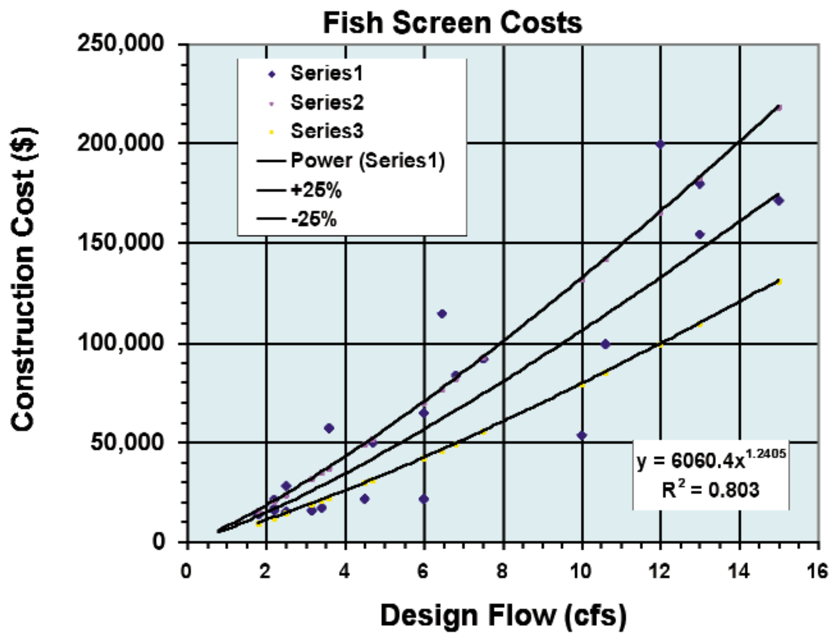
Developing Cost Curves

Following are some examples of cost curves created using cost data that can be found on the state web sites for Washington and Idaho.

Figure 1 shows a curve based on screen costs listed on the Washington State web site. There appears to be a lot of variation in costs based on the size of the screen. For example, there are a couple of points for screens between 10 and 12 CFS that have widely divergent costs – one cost $100,000 and the other $200,000. The same thing is true for a couple of points at about 6 CFS, where one screen cost $20,000 and the other $120,000. Clearly costs vary from site to site.

Some of the variation is also explained, though, by a lack of standardization of which items were included in the costs. The Washington web site had adjusted all of the screen costs to 1999 price levels, but some of

Figure 2. Washington State fish screen costs, 1 to 15 CFS (± 25%)



the costs, especially for the larger screens, weren't adjusted for other criteria. These points include a lot of USBR reclamation sites as well as Washington sites. When USBR built the first 20 diversions from 1984 to 1990, we used a 0.5 foot per second (ft/s) approach velocity. In our phase II program, which covered another 60 sites, we used 0.4 ft/s. That change in approach velocities makes a large difference in cost per CFS. Thus, when looking at the data, it is important to know what criteria were used so that appropriate adjustments can be made. This will ensure that the final curve is based on comparable costs.

Figure 2 includes curves drawn 25% above and 25% below the curve shown in

Figure 3. Washington State fish screen costs, 1 to 58 CFS (± 25%)

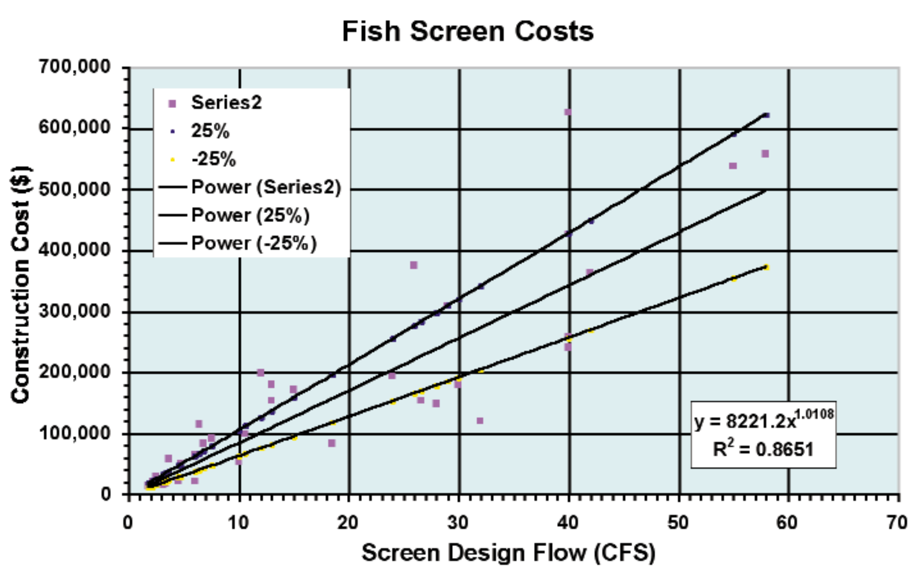


Figure 4. Washington State fish screen costs, 1 to 210 CFS (± 25%)

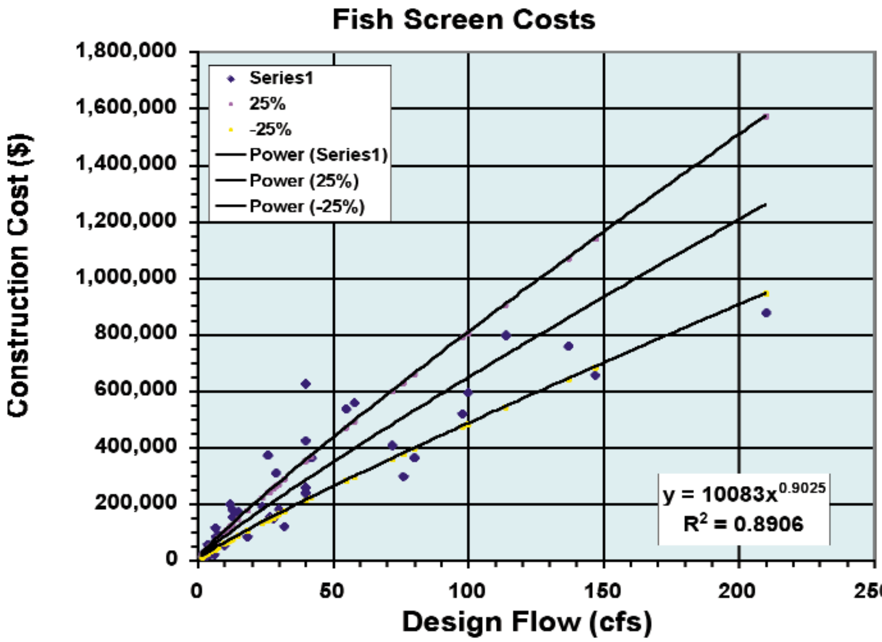


Figure 1. When estimating the cost to restore a new project site, it can be useful to locate the project on the curve based on the screen's design parameters. Then, using other information about the project (for example, how difficult the conditions at the site may be, or how many regulatory issues will need to be addressed), the cost may be adjusted within the plus and minus 25% curves. Quite a bit of individual judgment must be used when estimating the cost for a specific site, but these curves can be useful for first approximations.

Figure 3 includes more project sites than were used to develop the curves in Figures 1 and 2. These new sites have screens that are larger than those in the first two figures, up to almost 60 CFS. The curve is much the same as for the first two figures, although slightly less steep. It appears that the average size of the diversions in a given watershed will influence the overall cost curve.

Projects with screens of an even greater size (up to 210 CFS) are included in Figure 4. Once again, the shape of the curve has changed relative to curves developed using only the smaller screens. This time, though, the curve has become steeper, giving further evidence that the cost curves are dependent on which projects are included. As a result, it is important to understand that the use of cost curves for initial project cost estimation is limited to rough initial cost approximations. Refined project costs must be obtained using data specific to each project site.

The curve in Figure 5 was developed using cost estimates for projects before their final design was completed. This is in contrast to the previous curves, which were developed using actual costs from completed projects.

CONCLUSION

Figure 6 is a representation of the decrease in variance in cost estimates as knowledge of a project site increases in detail. With decreasing variance in cost estimates comes increased confidence that the estimate will be close to the final project cost at any given site. As the project planning process progresses, the known details about a project location accumulate and the accuracy of cost approximations grows.

Figure 5. Washington State fish screen costs, initial estimates

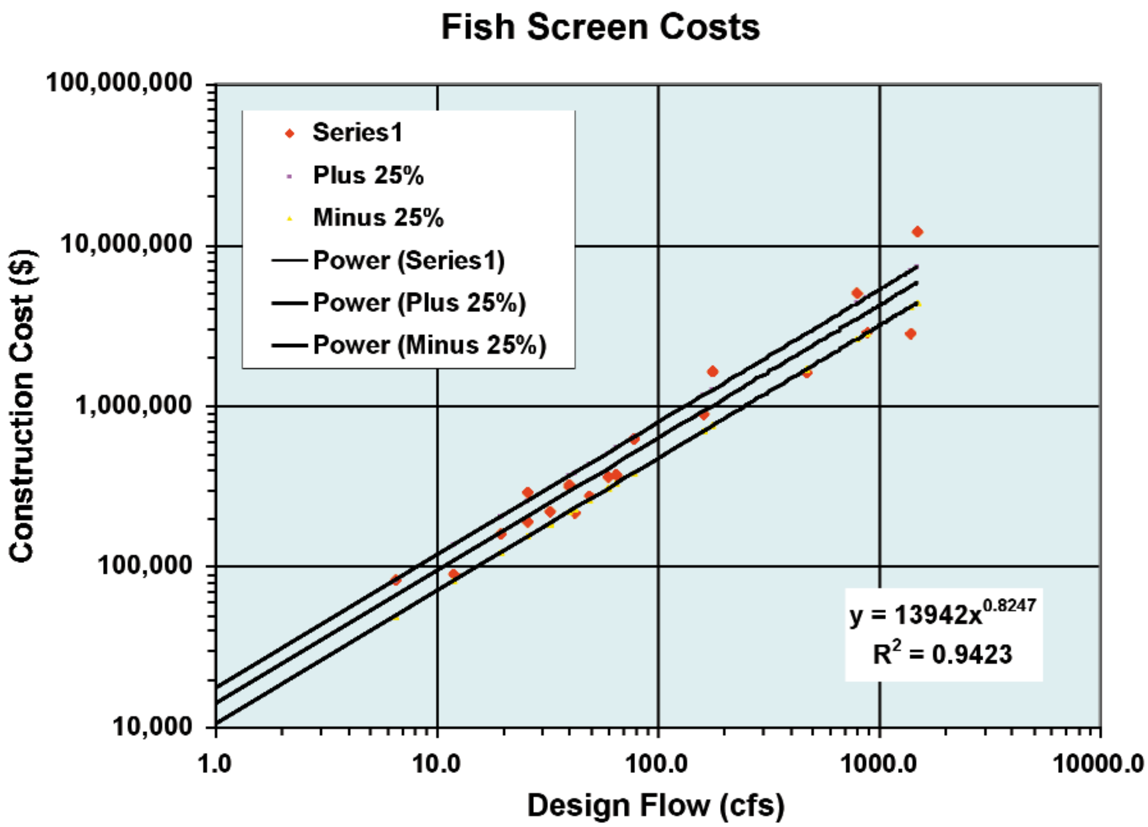
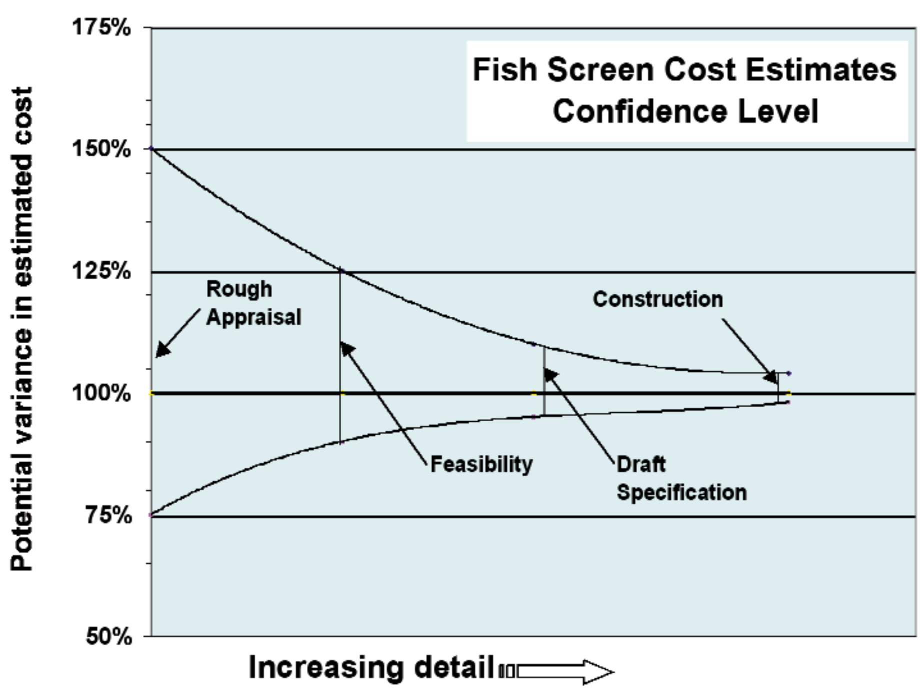


Figure 6. Fish screen cost estimates confidence level



Estimating project costs requires both a general understanding of the amounts spent on a variety of similar projects as well as very specific knowledge of the site to be treated in the project. Using fish screens as an example, it is possible to see that while generalized methods of estimating project costs have some utility in generating rough cost estimates, it is crucial to have a detailed understanding of a given site in order to refine the estimate. This makes it difficult to develop cost estimates on a watershed or larger scale, and as a result, only rough estimates can be made at higher levels.